RESILIENT AND ECONOMICALLY VIABLE COASTAL COMMUNITIES

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OVERVIEW

The current fleet of vessels off the U.S. West Coast and Alaska is less diverse than at any point in the past 30 years.

EXECUTIVE SUMMARY

Human dimensions of the California Current Large Marine Ecosystem are included in several sections of the IEA. Human activities that potentially influence the status of natural ecosystem components are detailed in the Human Pressures section of the report. In the Management Evaluation and Scenarios section of the IEA, human dimensions are included as economic outcomes of alternative futures. Additionally, in this section, we used economic models to predict the response of fishing fleets to various management options.

In this section, we focus on the status and trends of coastal communities that are dependent on the natural resources of the California Current. This new research is ongoing and incomplete, and here we provide details of what we have completed thus far and future research directions.

In this chapter, we identify a set of proposed indices. Each index is a composite of 3 to 5 metrics and, considered together, the indices focus on the degree to which coastal communities rely on marine resources and are socioeconomically vulnerable. The integrated ecosystem assessment focuses on status and trends in focal species and focal components. In much the same way, a focus on those coastal communities most directly linked to the ecosystem via fishing provides a first step in index selection.

The California Current lies adjacent to and is a part of the socioeconomic fabric of numerous coastal communities in Washington, Oregon and California, including 123 communities previously identified as "dependent" on or "engaged" in West Coast fisheries through a fisheries Data Envelopment Analysis methodology (Sepez et al. 2007). While coastal communities are linked to the California Current ecosystem in numerous ways, in the context of the IEA we will initially focus on the communities linked to the CCLME via fishing. The Commercial Fishing Reliance Index was adapted from work on the U.S. East Coast because the index allows for the integration of readily accessible data on a multi-year basis, therefore elucidating long term trends, and also identifies communities that are expected to respond to changes in environmental conditions, potentially proving to be salient in vulnerability analyses (Clay and Olson 2008, Colburn and Jepson 2012).

Once the communities most reliant on commercial fisheries are identified, statistical analyses of subsequent indices can assess these communities in terms of their socioeconomic vulnerability. Our indices of socioeconomic vulnerability include a Population Composition Index, Poverty Index, Personal Disruptions Index and a Fishery Income Diversification Indicator.

While much of this approach has been successfully developed and implemented for coastal communities on the U.S. East Coast and Gulf Coast (Jacob et al. 2012), this method of measuring and evaluating socioeconomic resilience is still in the early stages of data collection and data organization for the communities of the coastal portions of the California Current Large Marine Ecosystem and the coastal communities of Alaska. These indices seek to account for socioeconomic vulnerability of California Current coastal communities and may therefore be linked to the CCIEA. Since data collection, organization, and analyses are ongoing, status and trends for these indices are not yet determined.

The Fishery Income Diversification Indicator presents a final single indicator, rather than an index, and is measured at the vessel level, as opposed to the community level. However this indicator provides some indication of status and trends for those individuals engaged with West Coast fisheries. Catches and prices from many fisheries exhibit high inter-annual variability leading to high variability in fishermen's income. Kasperski (AFSC) and Holland (NWFSC) recently examined more than 30,000 vessels fishing off the West Coast and Alaska over the last 30 years. This work shows that variability of annual revenue can be reduced by diversifying fishing activities across multiple fisheries or regions. Diversification can be measured with the Herfindahl-Hirschman Index (HHI), which ranges from a high 10,000 for vessel that derives all its income from a single fishery and declines toward zero as revenues are spread more evenly across more fisheries.

Levels of diversification for groupings of vessels vary greatly, and levels of diversification for these vessel groupings exhibit different trends over time. The current fleet of vessels fishing off the coasts of the U.S. West Coast and Alaska (those that fished in 2010) is less diverse than at any point in the past 30 years. The trends over time are due to both entry and exit of vessels and changes for individual vessels. Over time, less diversified vessels have been more likely to exit the fishery, which increases the average diversification level (decreases HHI). However, vessels that remain in the fishery have become less diversified, at least since the mid 1990s, and newer entrants have generally been less diversified than earlier entrants. The overall result is a moderate decline in average diversification (increase in HHI) since the mid 1990s or earlier for most vessels groupings. Notwithstanding these trends in average diversification, there are wide range of diversification levels and strategies within as well as across vessel classes and some vessels remain highly diversified.

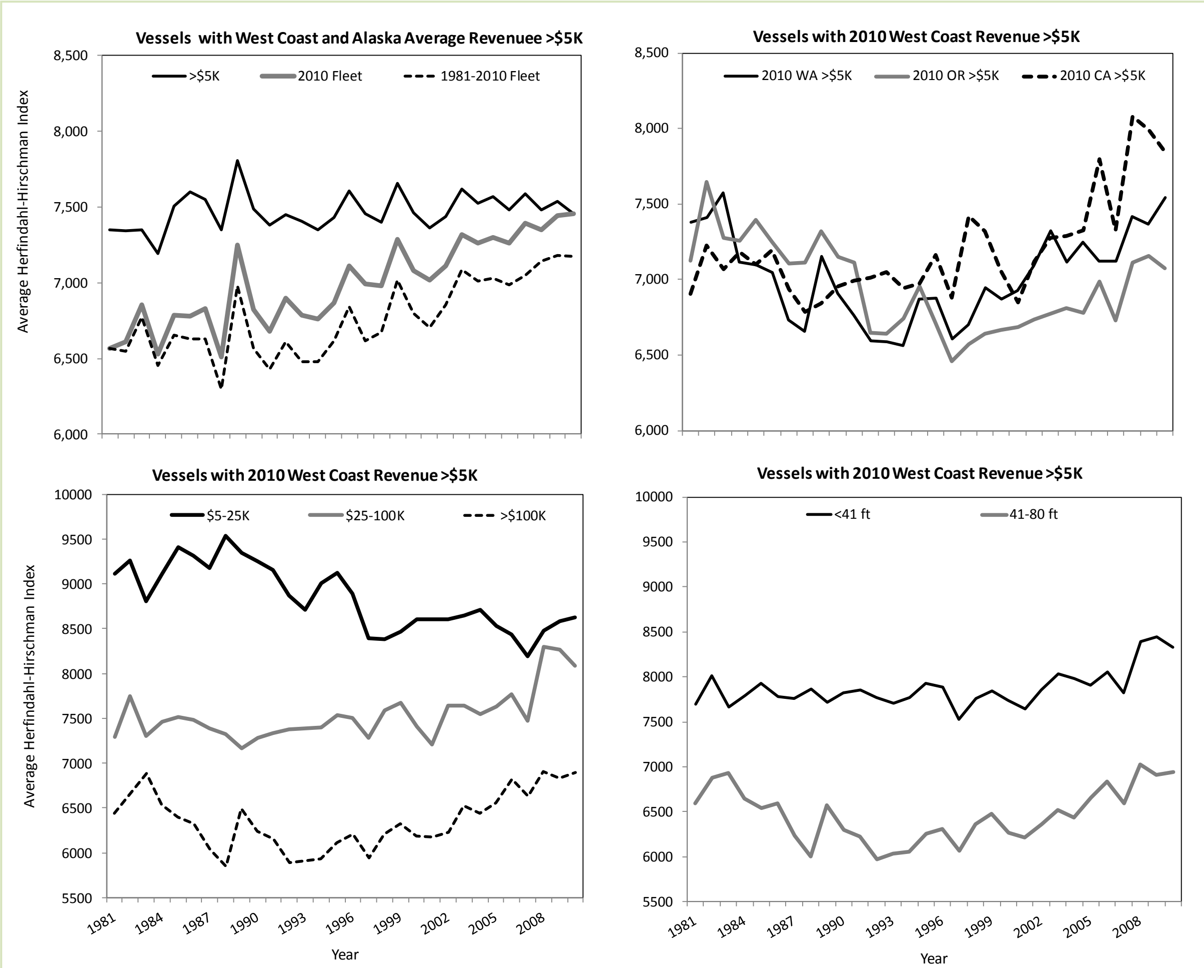

Figure HD. Trends in average diversification for US West Coast and Alaskan fishing vessels with over $5k in average revenues (top left panel) and for vessels with 2010 West Coast revenue >$5k (top right and bottom panels).

DETAILED REPORT

We evaluate a set of four indices and one indicator, designed to measure status and trends of fishing reliance and socioeconomic vulnerability within the coastal human communities of the CCLME. Through this effort, we identify currently available data useful in assessing vulnerability, discuss current efforts that will be useful for future analyses, and identify gaps in human dimensions research.

The indices described here have been developed for and applied to a separate vulnerability assessment process for the coastal communities of the Southeast and Northeast regions (Jepson and Colburn in press), building upon prior social indicators work in coastal and fisheries contexts (Cutter 1996, Cobb and Rixford 1998, Pollnac et al. 2006, Jepson and Jacob 2007, Cutter et al. 2008). These vulnerability indices and vulnerability analyses of coastal communities will be replicated for the human communities adjacent to and integrated with the CCLME. Similar assessments of fishing reliance and socioeconomic vulnerability are already underway in the Alaska region and, through the development of this work nation-wide, a standardized approach to coastal community vulnerability will be applied throughout the U.S. fisheries management regions of North America.

As with Colburn and Jepson's (Colburn and Jepson 2012) use of Walker et al. (Walker et al. 2004), we take the view that resilience refers to the adaptive capacity of a community faced with socioeconomic and ecological duress. The indicators here are oriented toward measures of community vulnerability, and a vulnerable status for any one community or set of communities could be offset by community-level resilience. Analytical measures of resilience typically require an examination of changes and responses over time and are often highlighted in the data by noticeable perturbations and disaster events. For example, faced with socioeconomic vulnerability evident in income and sociological health measures, communities of Columbia River gillnetters have nonetheless exhibited resilience in maintaining their livelihoods, even in the face of emergent environmental and policy challenges (Martin 2008).

Much of the socioeconomic data necessary for each of the evaluated indices is available nationally through the U.S. Census's American Community Survey (ACS). Fisheries data used in the indices are collected for fisheries management needs in each region, and regional fisheries information networks such as the Pacific Fisheries Information Network (PacFIN) and Alaska Fisheries Information Network (AKFIN) maintain similar data necessary for the fishing reliance and vulnerability indices and analyses. For this reason, the coastal community vulnerability analysis approach pioneered in the Southeast and Northeast regions of the U.S. (Colburn and Jepson 2012, Jacob et al. 2012, Jepson and Colburn in press) is appropriate in other regional contexts, including within the coastal communities of the U.S. West Coast (i.e. the coastal portion of the CCLME).

The Fishery Income Diversification Indicator is the final indicator discussed in this work and it presents something of a special case as compared to the first four indices presented. The Fishery Income Diversification Indicator is measured at the fishing vessel level, as compared to the other four indices of *community level* vulnerability. However, Fishery Income Diversification is nevertheless worthy of inclusion because this indicator provides information on the status and trends for this particular aspect of CCLME-dependent human activities, where the other included indices of vulnerability are still in the relatively early phases of data collection and analysis.

The first of the four indices discussed here, the Commercial Fishing Reliance Index, will initially be applied to the complete set of coastal communities designated by the U.S. Census as "places," and geographically located within the CCLME's coastal counties. Once the set of communities reliant on commercial fishing are determined through a confirmatory factor analysis applied to the data included with the Commercial Fishing Reliance Index, we can apply a subsequent set of factor analyses with reference to the additional indices of socioeconomic vulnerability. In this way, we will have some measures of vulnerability status for a set of coastal communities integrated with the CCLME (Figure HD1).

All coastal communities* adjacent to the CCLME

↓↓

Factor analysis applied to ***Commercial Fisheries Reliance Indicators*** for all coastal communities

↓↓

Commercial Fishery Reliant Communities

↓↓

Factor analysis applied to ***Poverty Indicators, Personal Disruption Indicators, and Population Composition Indicators*** for all Commercial Fishery Reliant communities

↓↓

Potentially Vulnerable CCLME Human Communities

Figure HD1. Diagram of indices and factor analysis approach toward vulnerability for the human communities of the CCLME. *As determined by the U.S. Census (i.e. U.S. Census-Designated Places [CDPs] with coastal counties adjacent to the CCLME)

INDICATOR SELECTION PROCESS

INDICATOR EVALUATION

COMMERCIAL FISHING RELIANCE INDEX

The California Current Large Marine Ecosystem supports and is integral to a diverse set of human communities and human activities. There are 1912 census-designated places (CDPs) in Washington, Oregon and California, of which an as yet unidentified number may currently be defined as dependent on commercial fishing to meet their socioeconomic needs. For the purposes of the CCIEA, the most productive approach is to initially focus on those CDPs which are directly linked to the CCLME's marine species through commercial fishing, thereby identifying the communities of interest. While broader measures of ecosystem-oriented human well-being, ecosystem interaction and community resilience may eventually be developed, such measures are often difficult to identify at the community level, do not as often rest on consistently collected data and are sometimes challenged for their limited utility and applicability (Raudsepp-Hearne et al. 2010, Duraiappah 2011).

The Commercial Fishing Reliance Index allows for the selection of communities most reliant on commercial fishing and therefore of particular interest to the CCIEA. The indicators included in the Commercial Fishing Reliance Index are primarily available as annually collected fisheries data maintained by the Pacific Fisheries Information Network (PacFIN), and employment data collected by the U.S. Census' American Community Survey (ACS). The indicators incorporated into the Commercial Fishing Reliance Index are the:

- Value of commercial fisheries landings per capita for each community
- Number of commercial fishing permits per capita for each community
- Processors with landings per capita for each community
- Percent employed in agriculture, fishing and forestry

We selected this index because it requires the integration of readily accessible data on a multi-year basis, and the index further points to communities that are expected to respond to changes in environmental conditions and potentially exhibit salience in concomitant vulnerability analyses. In the subsequent indices, we provide proposed indicators of condition for the selected commercial fishing-reliant communities (Kershner et al. 2011).

DEFINING 'COMMUNITY' AND COMMUNITIES OF INTEREST

Northwest Fisheries Science Center and Alaska Fisheries Science Center social scientists previously identified 123 Washington, Oregon and California coastal communities "dependent on" or substantially "engaged In" commercial fishing to meet their socioeconomic needs through a Data Envelopment Analysis (Sepez et al. 2007). The Commercial Fishing Reliance Index evaluated here was developed in part to establish standard social indicators for coastal communities nation-wide, and the application of this index to the communities of the CCLME will likely result in a set of fishing-dependent communities similar to those identified by the prior technical memorandum (Norman et al. 2007). The NWFSC technical memorandum identified 40 Washington communities, 31 Oregon communities, and 52 California communities that were either substantially “dependent on” or “engaged in” commercial fisheries, including CCLME fisheries in particular, to meet their social and economic needs. Although the Data Envelopment Analysis (DEA) approach employed in the technical memorandum has been successfully employed in other fisheries and regions (Alsharif and Miller 2012), the advantage of the Commercial Fishing Reliance Index evaluated here is that it presents a novel organization and analysis of existing fisheries data that simplifies the DEA approach (Sepez et al. 2007) by reducing the component indicators of the community fishing dependence measure from 15 to just 4 (Jacob et al. 2010, Jepson and Colburn in press). Both the DEA approach to identifying communities of interest and the Commercial Fishing Reliance Index utilized here rest on a place-based definition of “community” that applies the U.S. Census’ Census-Designated Place (CDP) approach to community identification (Sepez et al. 2007; Colburn and Jepson 2012). Examining CCLME human communities as West Coast places designated by the U.S. Census allows for ready use of the extensive demographic and socioeconomically important information available through the American Community Survey (ACS).

The California Current is an important marine ecosystem for coastal communities engaged in commercial fisheries. In prior socioeconomic profiles of West Coast fishing communities in Washington, Oregon and California, community profile selection thresholds were based upon fishery landings, permits and landings value data inputs for seven CCLME fishery management groups of commercial interest (Norman et al. 2007), including:

- Crab
- Shrimp
- Groundfish
- Highly Migratory Species
- Coastal Pelagic Species
- Salmon
- Shellfish

The Commercial Fishing Reliance Index will similarly account for fishing indicators relative to each of the above fishery management and species group. Following the IEA indicator evaluation approach described with respect to the Puget Sound case study (Kershner et al. 2011), the selection of the Commercial Fishing Reliance Index rests on peer-reviewed literature or specific management mandates. Relevant indicator selection considerations for the Commercial Fishing Reliance Index include the following evaluation criteria:

- Theoretically-sound
    - Assessment of U.S. Gulf Coast communities (Jacob et al. 2010)
- Relevant to management concerns
    - Executive Order 12898
    - MSFCMA National Standard 8
- Concrete & Numerical
    - Factor loading on the indicators presents defensible results for other coastal communities (Jacob et al. 2010, Jepson and Colburn in press)
- Historical data or information available

- ACS data available on 5-year, 3-year and annual cycle, depending on community size, beginning in 2000
    - Fisheries data available annually through PacFIN beginning in1981
- Operationally simple
    - (Jacob et al. 2010)
- Broad spatial coverage
    - (Jacob et al. 2010)
- Continuous time series
    - ACS data available on 5-year, 3-year and annual cycle, depending on community size
    - Fisheries data available annually at minimum through PacFIN
- Understood by the public & policymakers
    - Community vulnerability and viability has been a prominent concern for the public within fishing and coastal communities (Hall-Arber et al. 2001, Colburn and Jepson 2012)
    - Policy makers have incorporated fishing community viability into federal management statutes (MSFCMA National Standard 8)
- History of reporting
    - Fishing community dependence, reliance and engagement reported in multiple contexts (Sepez et al. 2005, Norman et al. 2007)
- Cost-effective
    - Based upon freely available ACS and PacFIN data
- Regionally/nationally/internationally compatible
    - Replicates approach for U.S. East Coast, Gulf Coast and Alaska Communities (Jacob et al. 2010, Jepson and Colburn in press)

POPULATION COMPOSITION INDEX

Once commercial fishing reliant-communities are identified by factor analyses applied to the Commercial Fishing Reliance Index, those communities which are likely to be most vulnerable to management changes, natural hazards and ecosystem pressures will be made apparent through factor analyses applied to indices of socioeconomic vulnerability. Since these indices are meant to very broadly measure community-level socioeconomic vulnerability, they then identify a set of communities vulnerable to a broad range of disruptions and pressures, both socioeconomic (e.g. fishery closures) and natural (e.g. large-scale coastal windstorms) in origin. The Population Composition Index, which quantitatively describes the social make-up of the human communities reliant on the fisheries of the CCLME, is the first such vulnerability index. The indices of socioeconomic vulnerability, including the Population Composition Index, rely on community-specific data pulled from Annual American Community Survey (ACS) datasets as maintained by the U.S. Census. The use of ACS data allows for the use of regularly updated data for each community identified by the Commercial Fishing Reliance Index. The Population Composition Index combines ACS data on race, gender and other demographics including:

- Percent of community identifying racially as “white alone”
- Percent of community with female single headed households
- Population age 0-5
- Percent that speak English less than well

For the Population Composition Index and subsequent indices developed from ACS and other sources, the U.S. Census's ACS data provides a source of secondary data that is regularly updated, allowing for trend monitoring for each community and index. However, ACS data are collected and released based upon community population thresholds. Coastal communities with populations equal to 65,000 and above feature ACS estimates on an annual basis. Communities home to populations equal to 20,000 and above are updated every three years. Communities with fewer than 20,000 people feature data releases which are updated every five years. In terms of consistent analyses and trend monitoring, these size-based data differences may prove problematic within the framework of the CCIEA.

For example, prior fishing community profiling work (Norman et al. 2007) identified coastal communities of varying population sizes in determining which U.S. West Coast communities were most "dependent" on, or "engaged" in commercial fisheries to meet their socioeconomic needs. Included among the set of communities that scored highly on DEA measures of fisheries dependence and engagement were large coastal communities like San Diego, California, with a population equal to 1,326,179, and Port Orford, Oregon, with a population of 1,133 (Sepez et al. 2007). Due to their large differences in population size, and the accompanying constraints connected to ACS data releases, these two probable communities of CCIEA interest could only be considered together within the socioeconomic vulnerability factor analyses every five years.

Following the indicator evaluation approach described with respect to the Puget Sound case study (Kershner et al. 2011), the selection of the Population Composition Index rests on peer-reviewed literature or specific management mandates. Relevant indicator selection considerations include the following evaluation criteria:

- Theoretically-sound
    - Assessment of U.S. East Coast communities (Jacob et al. 2012)
- Relevant to management concerns
    - Executive Order 12898
    - MSFCMA National Standard 8
- Concrete & Numerical
    - Factor loading on the indicators presents defensible results for other coastal communities (Jacob et al. 2012)
- Historical data or information available
    - ACS data available on 5-year, 3-year and annual cycle, depending on community size, beginning in 2000
- Operationally simple
    - (Jacob et al. 2012)
- Broad spatial coverage
    - (Jacob et al. 2012)
- Continuous time series
    - ACS data available on 5-year, 3-year and annual cycle, depending on community size
- Understood by the public & policymakers
    - Community vulnerability and viability has been a prominent concern for the public within fishing and coastal communities (Hall-Arber et al. 2001, Colburn and Jepson 2012)
    - Policy makers have incorporated fishing community viability into federal statutes (MSFCMA National Standard 8)
- History of reporting

    - General demographic profiles reported in fishing community reporting contexts (Sepez et al. 2005, Norman et al. 2007)
- Cost-effective
    - Based upon freely available ACS and PacFIN data
- Regionally/nationally/internationally compatible
    - Replicates approach for U.S. East Coast, Gulf Coast and Alaska Communities (Jacob et al. 2010, Jepson and Colburn in press)

POVERTY INDEX

In addition to the Population Composition Index, factor analyses on poverty indicators can offer assessments of socioeconomic vulnerability for coastal communities. A Poverty Index developed by fisheries social scientists in the Southeast and Northeast regions, following prior work on community vulnerability to natural hazards (Cutter 1996, Cutter et al. 2000, Jacob et al. 2012) provides a means of assessing relative well-being, vulnerability and resilience potential of fishing reliant communities.

The Poverty Index, employed in measuring socioeconomic vulnerability of coastal communities, includes indicators that account for the:

- Percent within the community receiving assistance
- Percent of families within the community living below the poverty level
- Percent of the community over 65 years old living in poverty
- Percent of the community under 18 years old living in poverty

For coastal communities, socioeconomic vulnerability indices were selected based upon ongoing, national research and the peer-reviewed support and management contexts for this approach is described below.   Relevant indicator selection considerations include the following evaluation criteria with respect to the Poverty Index:

- Theoretically-sound
    - Assessment of U.S. East Coast communities (Jacob et al. 2012)
- Relevant to management concerns
    - Executive Order 12898
    - NOAA MSFCMA National Standard 8
- Concrete & Numerical
    - Factor loading on the indicators presents defensible results for other coastal communities (Jacob et al. 2012)
- Historical data or information available
    - ACS data available on 5-year, 3-year and annual cycle, depending on community size, beginning in 2000
- Operationally simple
    - (Jacob et al. 2012)
- Broad spatial coverage
    - (Jacob et al. 2012)
- Continuous time series
    - ACS data available on 5-year, 3-year and annual cycle, depending on community size

- Understood by the public & policymakers
    - Community vulnerability and viability has been a prominent concern for the public within fishing and coastal communities (Hall-Arber et al. 2001, Colburn and Jepson 2012)
    - Policy makers have incorporated fishing community viability into federal statutes (MSFCMA National Standard 8)
- Cost-effective
    - Based upon freely available ACS and PacFIN data
- Regionally/nationally/internationally compatible
    - Replicates approach for U.S. East Coast, Gulf Coast and Alaska Communities (Jacob et al. 2010, Jepson and Colburn in press)

PERSONAL DISRUPTIONS INDEX

As a companion to the Poverty Index, the Personal Disruptions Index developed by fisheries social scientists in the Southeast and Northeast regions, following prior work on community vulnerability (Cutter 1996, Jacob et al. 2012), provides a means of assessing relative well-being of commercial fishing reliant communities. Relatively frequent personal disruptions within the community are linked to increased overall vulnerability to natural hazards and other events and changes associated with livelihood and social impacts (Cutter et al. 2000, Jacob et al. 2012).

The Personal Disruptions Index, employed as a way of measuring socioeconomic vulnerability, includes indicators that account for:

- Percent within the community unemployed
- Uniform Crime Reporting (UCR) crime statistics index
- Percent of the community with no diploma
- Percent of the community living in poverty
- Percent of separated females in the community

For coastal communities, socioeconomic vulnerability indices were selected based upon ongoing, national research, and the peer-reviewed support and management contexts for this approach are described below. Relevant indicator selection considerations for the Personal Disruptions Index include the following evaluation criteria:

- Theoretically-sound
    - Assessment of U.S. East Coast communities (Jacob et al. 2012)
- Relevant to management concerns
    - Executive Order 12898
    - NOAA MSFCMA National Standard 8
- Concrete & Numerical
    - Factor loading on the indicators presents defensible results for other coastal communities (Jacob et al. 2012)
- Historical data or information available
    - ACS data available on 5-year, 3-year and annual cycle, depending on community size , beginning in 2000
    - UCR crime statistics index available annually beginning in 1930
- Operationally simple

    - (Jacob et al. 2012)
- Broad spatial coverage
    - (Jacob et al. 2012)
- Continuous time series
    - ACS data available on 5-year, 3-year and annual cycle, depending on community size
    - UCR crime statistics index available annually
- Understood by the public & policymakers
    - Community vulnerability and viability has been a prominent concern for the public within fishing and coastal communities (Hall-Arber et al. 2001, Colburn and Jepson 2012)
    - Policy makers have incorporated fishing community viability into federal statutes (MSFCMA National Standard 8)
- Cost-effective
    - Based upon freely available ACS, PacFIN data and FBI Uniform Crime Reporting (UCR) data
- Regionally/nationally/internationally compatible
    - Replicates approach for U.S. East Coast, Gulf Coast and Alaska Communities (Jacob et al. 2010, Jepson and Colburn in press)

FISHERY INCOME DIVERSIFICATION INDICATOR

Catches and prices from many fisheries exhibit high inter-annual variability leading to variability in the income derived by fishery participants. The economic risk posed by this variability might be mitigated in some cases if individuals participate in several different fisheries; particularly if revenues from those fisheries are uncorrelated or vary asynchronously. Crop diversification is a common means of reducing risk in agriculture taking advantage of asynchronous variation in yields response and prices to minimize idiosyncratic risk (Heady 1952, Johnson 1967). Another common strategy in agriculture, particularly in semiarid regions with high fine scale variation in rainfall, is to farm a number of geographically separated plots to ensure some will be in areas with sufficient rainfall (Rosenzweig and Binswanger 1993). McCloskey argues that risk reduction was the motivation for English farmers for "scattering each man's holdings in dozens of small strips" was, though inefficient, practiced as a risk reduction strategy (McCloskey 1976). A number of authors have argued that common property provides an important means risk reduction that may be undermined by privatization (Bromley and Chavas 1989, Thompson and Wilson 1994, Nugent and Sanchez 1998). This literature relates primarily to grazing lands held in common to protect against the potential spatial for variation in rainfall that would impact small private holdings but smooth risk for herders utilizing a much larger area held in common, but similar strategies apply to fishermen. While formal insurance programs do not exist, fishermen's fishing strategies provide a means to reduce risk, in particular by diversifying their fishing activity across a variety of fisheries or areas(Oostenbrugge et al. 2002, Minnegal and Dwyer 2008). There is also a growing literature that suggests that fishermen should adopt portfolio approaches to their species composition to achieve the lowest variance in income for any level of expected return (Smith and McKelvey 1986, Baldursson and Magnusson 1997, Hilborn et al. 2001, Perusso et al. 2005, Sethi et al. 2012).

We measure diversification of West Coast and Alaskan fishing vessel's gross revenues across species groups and regions each year. We utilize the Herfindahl-Hirschman Index (HHI) defined as:

$$H = \sum_{i=1}^{S_j} \sum_{j=1}^{4} p_{ij}^2, \quad (1)$$

where p_{ij} represents percent (ranging from 0 to 100) of an individual's total gross revenues derived from species group i in region *j*. We define p_{ij} to be the percent of a vessel's total annual gross revenue from one of 40 different species groupings in one of four regions – the Bering Sea/Aleutian Islands, Gulf of Alaska, Alaskan in-state waters, and the WC (Table HD1). Not every species group is caught in each region, so there are a total of 84 total region-specific species groupings. HHI theoretically ranges from zero when revenues are spread amongst an infinite number of fisheries to 10,000 for a fishing operation that derives all revenue for a single fishery. Thus, the less diversified an individual's revenue sources are, the higher the HHI. We evaluate how diversification has changed over time for various fleet groups. To explore how diversification of fishery income affects year-to-year variation and thus financial risk, we estimate the statistical relationship between HHI and the coefficient of variation (CV) of gross revenues for each vessel across years.

Socioeconomic vulnerability indicators were selected based upon ongoing, national research, and the peer-reviewed support and management contexts for this approach are described below. Relevant indicator selection considerations for the Fishery Income Diversification Indicator include:

- Theoretically-sound
  - (Perusso et al. 2005, Sethi et al. 2012)
- Relevant to management concerns
  - Relevant to fishery management plans and the groundfish trawl catch share program
- Responds predictably & is sufficiently sensitive to changes in a specific management action or pressure
  - Decreased diversification seems a likely result of recent management shifts
- Concrete & Numerical
  - Estimate based upon the statistical relationship between the Herfindahl-Hirschman Index (HHI) and the coefficient of variation (CV) of gross revenues for each vessel across years
- Historical data or information available
  - PacFIN data available beginning in 1981
- Operationally simple
- Broad spatial coverage
  - Applied on the vessel level across the CCLME
- Continuous time series
  - PacFIN data available annually at minimum
- Understood by the public & policymakers
  - Portfolio diversification typically understood as desirable in financial and agricultural contexts
- Cost-effective
  - Based upon freely available PacFIN fisheries data
- Regionally/nationally/internationally compatible
  - Similar analysis conducted relative to Alaskan fisheries, and is possible for other regions

Table HD1: Species groups used for diversification indices

West Coast	Alaska
Pacific Whiting	Pacific Cod
Dover Sole, Thornyheads, Sablefish	Flatfish
Rockfish and Flatfish	Rockfish
Skate, Dogfish, Sharks	Atka Mackerel
Pacific Halibut	Pollock
California Halibut, Croaker	Other Groundfish
Pink Shrimp	Sablefish
Other Prawns and Shrimp	Pacific Halibut
Crab	Herring
Salmon	Chinook Salmon
Tuna	Sockeye Salmon
Herring	Coho Salmon
Coastal Pelagics	Pink Salmon
Echinoderms	Chum Salmon
Other Shellfish	Other Salmon
Squid	Red King Crab
Other Species	Other King Crab
	Opilio Crab
	Other Snow Crab (Bairdi)
	Other Crab
	Scallops
	Other Shellfish
	Other Species

STATUS AND TRENDS

MAJOR FINDINGS

Estimating trends in both the reliance on commercial fishing and the general vulnerability of coastal communities to ecosystem shifts and other stresses is challenging. Prior researchers have linked natural resource dependence, including fishing, to community vulnerability (Jacob et al. 2012). For this reason, we must first assess which west coast communities are most reliant on fishing, and then determine which communities among these are most vulnerable according to factor analyses of the concomitant indices of population composition, poverty and personal disruptions. Measures of fishery income diversification provide additional opportunities to assess vulnerability to risk.

However, as a single indicator, the Fishery Income Diversification indicator is somewhat problematic within the context of the CCIEA. Because fishermen can access the resources of multiple ecosystems, the Fishery Income Diversification Indicator requires the inclusion of North Pacific fisheries data in order for it to broadly account for income diversification. This capacity for multiple ecosystem access may render this indicator challenging in terms of its connection to the CCLME. The mobility of fishermen confounds at least one of the indicator evaluation criteria presented in the Puget Sound indicator evaluation approach (Kershner et al. 2011), that of predictability and sensitivity to changes in a specific ecosystem attributes.

SUMMARY AND STATUS OF TRENDS

COMMERCIAL FISHING RELIANCE INDEX, POPULATION COMPOSITION INDEX, POVERTY INDEX, PERSONAL DISRUPTIONS INDEX

Until we can determine which communities are most reliant on commercial fisheries through a factor analysis applied to the Commercial Fishing Reliance Index, and data for each of the connected vulnerability indices is developed for those communities, complete information on coastal community status and trends will not be available for the CCLME.

FISHERY INCOME DIVERSIFICATION INDICATOR

We work with a large data set that includes annual landings and revenues between 1981 and 2010 by species, port and vessel from all commercial fisheries in the US EEZ off the West Coast and Alaska. We present analysis based on 30,757 vessels with average fishing revenues over $5000 (adjusted to 2005 values) and at least two years of documented landings. The large data set enables us to identify trends in diversification and relationships between diversification and variation in revenues despite the relationship being very noisy. We also consider a number of subsets of the larger fleet categorized by average revenues, length and whether they had landings in West Coast states (i.e., excluding vessels with revenue only from Alaska).

Average fishery revenue diversification of West Coast and Alaskan fishing vessels is variable but shows distinct trends over time (Figure HD2). The HHI for most vessel groups, though erratic, has generally been increasing over time meaning that diversification of fishery income has been declining. The current fleet of vessels on the US West Coast and in Alaska (those that fished in 2010) is less diverse than at any point in the past 30 years. For smaller vessels diversification has generally been declining (HHI increasing) since

1981. For larger vessels, diversification increased through the early 1990s but has mostly declined since. The causes of the decline in diversification are not completely clear and probably vary by fleet sector. One likely factor that correlates with the observed trend is the successive implementation and tightening of limited access programs and later individual quota programs. By the mid-1990s, entry into new fisheries was no longer possible for most vessels since nearly all fisheries had moratoriums on entry and many were beginning to reduce fleets through attrition, vessel buybacks or catch share programs. These programs limit fishermen's ability to move into new fisheries and often push out less active participants from a fishery. This is often necessary to limit catch and improve economic viability of the remaining participants, but it can also result in decreased diversification. Vessels that were in the fishery since 1981 have maintained a higher level of diversification than the overall fleet while vessels that entered later tend to be less diversified possible due to entry moratoriums in many fisheries. Diversification trends are somewhat more erratic for the current fleet of West Coast vessels -- i.e., vessels with at least $5000 in revenues from landings in WA, OR or CA in 2010. For some vessels categorizations (e.g., larger vessels and each state's fleet overall) diversification tended to increase (HHI decline) through the mid-1990s and then trend upward thereafter.

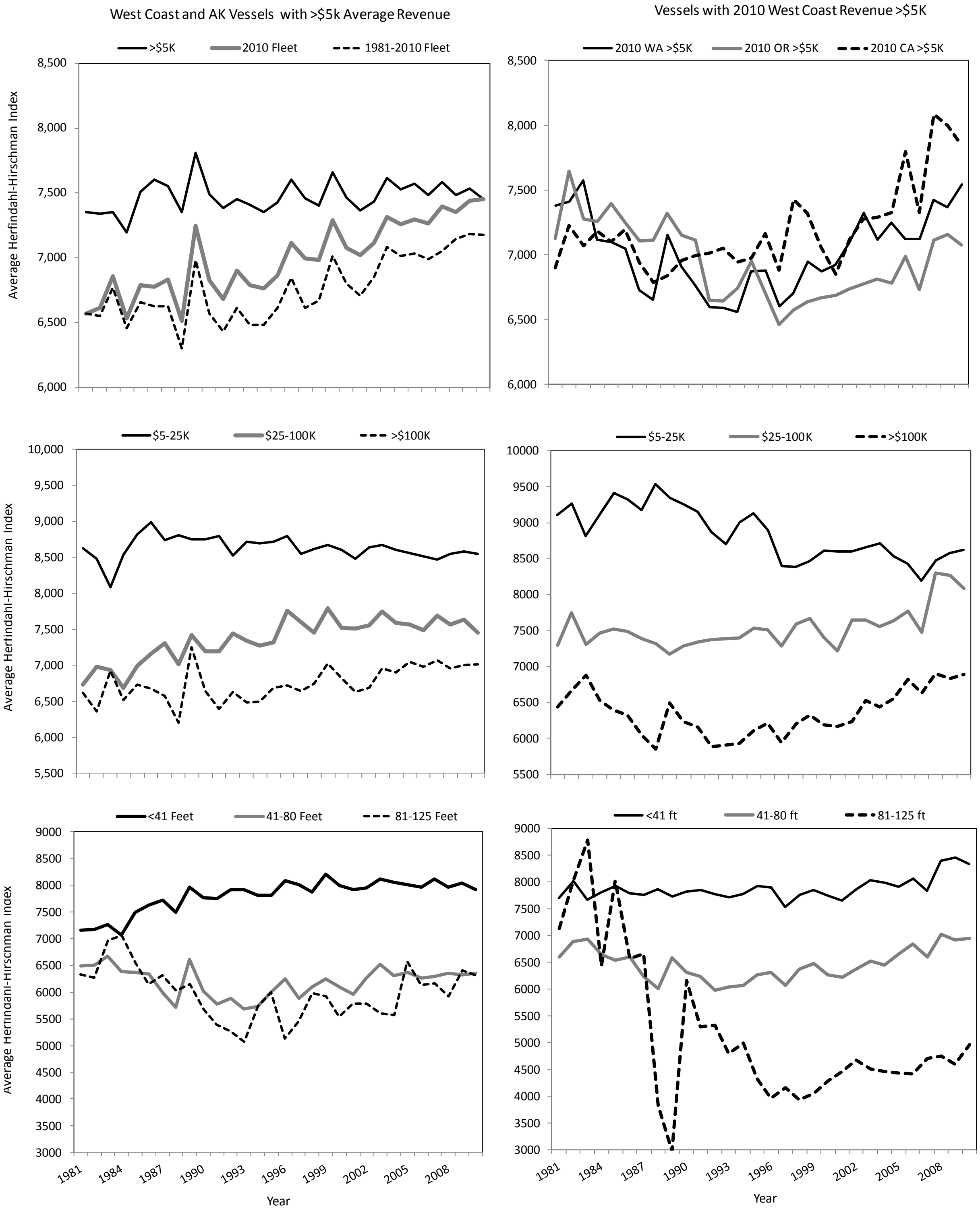

Figure HD 2. Trends in average diversification for US West Coast and Alaskan fishing vessels (left panels) and the 2010 West Coast Fleet (right panel) filtered by all vessels with over $5k in average revenues (top panel), by average gross revenues classes (middle panel) and by vessel length classes (bottom panel). The trend for

West Coast vessels 81-125 ft (bottom right) is erratic in early years because it represents only 3-4 vessels through 1989 and 15-17 thereafter.

While we can see some clear trends in diversification for various classes of vessels over time, there is wide variation in the degree of diversification across vessels within each class (Figure HD3). Higher earning and large vessels tend to be more diversified on average than smaller vessels and those with lower earnings. With the exception of the largest vessels, the current 2010 West Coast fleet appears to be less diversified on average than the larger fleet which includes all vessels from the West Coast and Alaska, and both current and former participants.

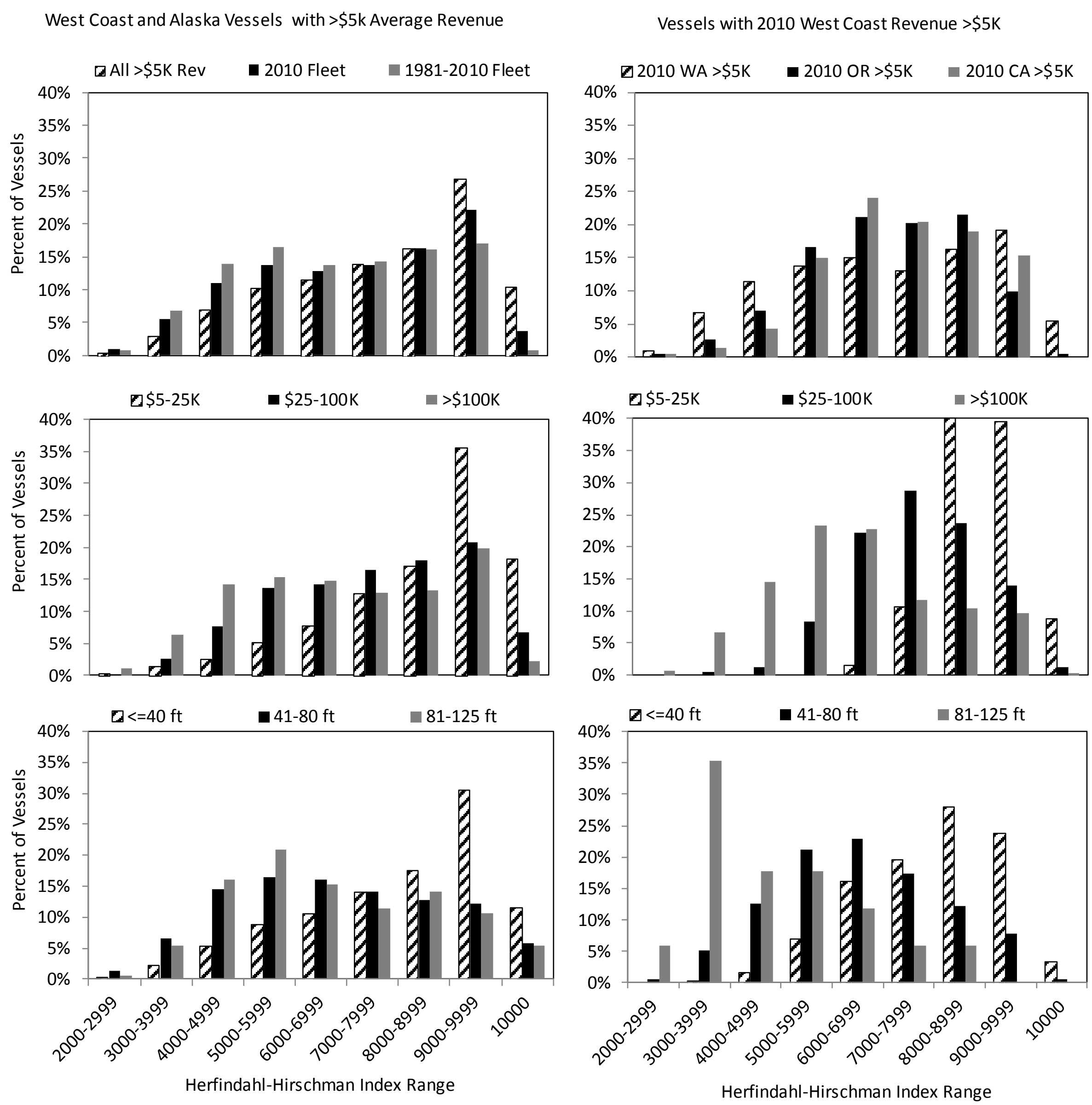

Figure HD3. Histograms showing percentage of vessels by ranges of Herfindahl-Hirschman index scores for US West Coast and Alaskan fishing vessels (left panels) and the 2010 West Coast Fleet (right panel) filtered by all vessels with over $5k in average revenues (top panel), by average gross revenues classes (middle panel) and by vessel length classes (bottom panel).

If vessels are able to diversify into multiple fisheries whose revenues vary independently or asynchronously, they should experience a reduction in volatility of revenues and thus financial risk. This is confirmed for all of our fleet groupings by estimating quadratic regressions of the CV of gross fishery revenue as a function of HHI and HHI squared. Our analysis indicates a dome shaped relationship between variability of individuals' income and income diversification which implies that a small amount of diversification actually increases risk for some fleet categories, but moderate amounts of diversification can substantially reduce the variability of income that individuals receive from fishing. The decrease in CV with increased diversification varies substantial across vessel categories (Figure HD4 and Table HD2), but for nearly all vessel categories there is a substantial decrease in CV when moving from a low level of diversification (e.g. a 90-10 split in revenues between two fisheries) to a high level of diversification (e.g., and 50-25-25 split). Annual revenues for fishing vessels in our sample have an average coefficient of variations of 0.78. To illustrate how the decrease in CV associated with diversification affects the range of annual income a vessel might expect, we calculate the 50th percentile range of gross revenues for four hypothetical diversification schemes based on the functional relationship between HHI and CV for all vessels with mean annual revenues greater than $5,000. The 50th percentile range of expected revenues contracts from a range of $67,000 to $244,000 with no diversification to a range of $107,000 to $207,000 with a 50-25-25 split of revenues across three fisheries.

Diversification across multiple fisheries can reduce variation and the associated financial risk. It can also increase the minimum annual revenue relative to average revenue, which should reduce the risk of a business failure. The ability of fishermen to diversify may be limited (or facilitated) by management approaches and regulatory actions. This should be a consideration when evaluating management actions, though in some cases management actions that reduce diversification are needed to remove excess capacity and promote efficiency.

There are a number of factors that may limit the feasibility or desirability of greater diversification. In many cases different fisheries require different gear that must be purchased and there are often costs of acquiring licenses and, increasingly, quota. It may also be the case that a vessel that can participate in several fisheries may be less efficient than more specialized vessels creating a trade-off between risk reduction through diversification and fishing efficiency. Exploration of this potential tradeoff would be an important extension of our research. Owners of multiple vessels can diversify by having individual vessels to specialize in different fisheries. Some fishermen may diversify their income with non-fishing sources. This seems particularly likely for vessels with low levels of revenue. We were unable to explore the degree or effects of this type of diversification due to a lack of data on non-fishing income. We hope to collect data on non-fishery income in future to explore this issue.

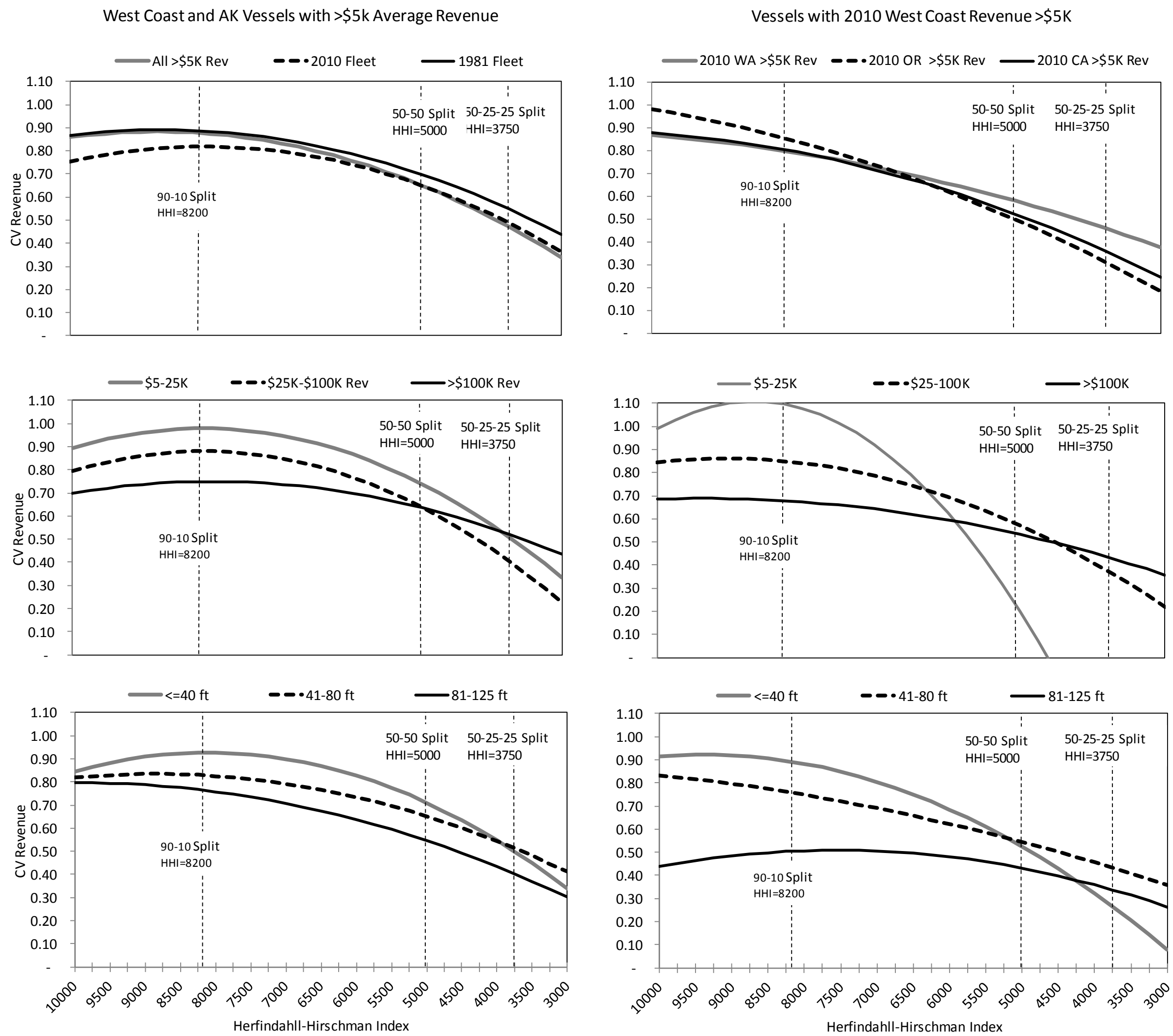

Figure HD4. Fitted relationships between the coefficient of variation (CV) of gross revenues for US West Coast and Alaskan fishing vessels (left panels) and the 2010 West Coast Fleet (right panel) filtered by all vessels with over $5k in average revenues (top panel), by average gross revenues classes (middle panel) and by vessel length classes (bottom panel).

Table HD2. Predicted coefficient of variation (CV) of gross fishery revenue for Herfindahl-Hirschman index scores associated with alternative diversification schemes for groupings of WC and AK fishing vessels.

	Predicted CV Herfindahl Index						
Vessel Category	Single Fishery	90-10 Split	50-50 Split	50-25-25 Split	%Drop Single Fishery to 50-25-25	Sample Size	Mean Revenue ($1000)
All >$5K Rev	0.84	0.90	0.69	0.49	41%	30,757	$ 155
2010 Fleet >$5K	0.75	0.82	0.65	0.49	35%	8,288	$ 272
1981-2010 Fleet >$5K	0.87	0.89	0.70	0.55	37%	3,880	$ 224
$5K-$25K Rev	0.89	0.98	0.74	0.51	43%	13,088	$ 12
$25K-$100K Rev	0.78	0.90	0.68	0.46	42%	10,081	$ 56
>$100K Rev	0.68	0.77	0.65	0.52	24%	7,588	$ 534
<40Feet	0.85	0.93	0.71	0.50	41%	23,905	$ 49
40-80 Feet	0.82	0.83	0.65	0.51	37%	5,868	$ 201
80-125 Feet	0.80	0.76	0.51	0.40	49%	617	$ 993
2010 WA >$5K	0.87	0.80	0.58	0.46	47%	404	$ 280
2010 OR >$5K	0.98	0.86	0.50	0.31	68%	455	$ 194
2010 CA >$5K	0.88	0.81	0.52	0.36	59%	460	$ 201
2010 WC $5-25K	0.99	1.09	0.20	n.a.	n.a.	162	$ 16
2010 WC $25-100K	0.85	0.85	0.57	0.37	56%	452	$ 59
2010 WC >$100K	0.68	0.68	0.53	0.43	37%	531	$ 380
2010 WC <40 Feet	0.91	0.89	0.52	0.27	71%	561	$ 90
2010 WC 41-80 Feet	0.83	0.76	0.54	0.43	48%	567	$ 283
2010 WC 81 -125 Feet	0.44	0.50	0.43	0.34	23%	17	$ 1,177

RISK

Until the community selections based upon the Commercial Fishing Reliance Index are complete, and the data extractions and analyses for the socioeconomic vulnerability indices are complete, we are not directly evaluating risk in this IEA. Fishery income diversification may provide some protection against risk and fisheries and income volatility, and the trends reflect decreasing diversification on the west coast, but the exposure and risks involved need further evaluation. In future, we will provide additional information on risks posed to fishermen and fishing communities according to their relative socioeconomic vulnerability measures.

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